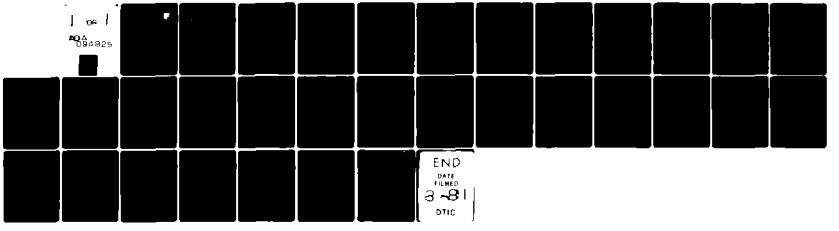
AD-A094 825 COMPUTER SCIENCES CORP FALLS CHURCH VA SYSTEMS DIV F/G 17/4
ELECTRONIC WARFARE - ELECTROMAGNETIC THREAT ANALYSIS SYSTEM, (E--ETC(U)
NOV 80 J A RUMMANS F30602-76-C-0376

UNCLASSIFIED RADC-TR-80-352 NL

1 OF 1
AD A094825



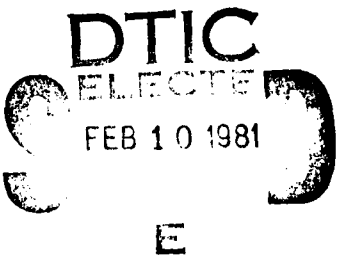
END
DATE FILMED
3-81
DTIC

RADC-TR-80-352
Final Technical Report
November 1980

ELECTRONIC WARFARE - ELECTROMAGNETIC THREAT ANALYSIS SYSTEM, (EW-ETAS)

Computer Sciences Corporation

John A. Rummans, Jr.



ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

X

This report has been reviewed by the RADC Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RADC-TR-80-352 has been reviewed and is approved for publication.

APPROVED: Marvin R. Clinch

MARVIN R. CLINCH
Project Engineer

APPROVED:

OWEN R. LAWTER, Colonel, USAF
Chief, Intelligence & Reconnaissance Division

FOR THE COMMANDER: John P. Huss

JOHN P. HUSS
Acting Chief, Plans Office

If your address has changed or if you wish to be removed from the RADC mailing list, or if the addressee is no longer employed by your organization, please notify RADC (IRAP) Griffiss AFB NY 13441. This will assist us in maintaining a current mailing list.

Do not return this copy. Retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: RADC-TR-80-352	2. GOVT ACCESSION NO.: AD-A094 825
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): ELECTRONIC WARFARE - ELECTROMAGNETIC THREAT ANALYSIS SYSTEM, (EW-ETAS)	5. TYPE OF REPORT & PERIOD COVERED: Final Technical Report 25 Jun 76 — 31 May 80
	6. PERFORMING ORG. REPORT NUMBER: N/A
7. AUTHOR(s): John A. Rummans, Jr.	8. CONTRACT OR GRANT NUMBER(s): F30602-76-C-0376
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Computer Sciences Corporation, Systems Division, Dept 835, 6565 Arlington Blvd, Falls Church VA 22046	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64750F, 20530105
11. CONTROLLING OFFICE NAME AND ADDRESS: Rome Air Development Center (IRAP), Griffiss AFB NY 13441	12. REPORT DATE: November 1980
	13. NUMBER OF PAGES: 33
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Same	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE: N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

RADC Project Engineer: Marvin R. Clinch (IRAP)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electromagnetic Warfare
Intelligence
Analysis
Computer System Architecture

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This effort was for the development of a system to assist FTD's analysts in their efforts to provide scientific and technical intelligence on Electronic Warfare and its threat. The system is called the Electronic Warfare - Electromagnetic Threat Analysis System (EW-ETAS). After progressing through the classic steps of systems development a subset of the full system capabilities was selected for immediate implementation as a "prototype" to demonstrate the system's potential. (Cont'd)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20 (Cont'd)

The effort was changed to make prototype demonstration on leased equipment at CSC and installation of the prototype software on equipment at FTD possible.

Individual subsystems were demonstrated and the prototype programs installed at FTD. The three (Intelligent Terminal, Graphics Terminal, and Desk Top Calculator) operational subsystems adequately demonstrated the soundness of the system development and design configuration. Future efforts that would implement a fully operational system will provide the FTD analyst with a highly valuable tool in the analysis of EW information for scientific and technical intelligence.

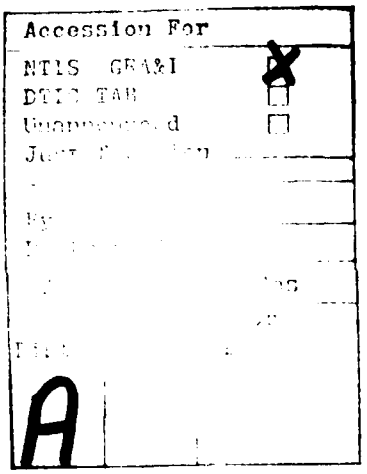


TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

EVALUATION

The EW-ETAS effort was conducted to develop the design for a system which would support the efforts of the personnel at the Foreign Technology Division (FTD) who are responsible for the area of Electronic Warfare analysis. The formal collection of data to determine the specific areas within which the greatest improvement might be gained was conducted by the contractor first. The subsequent data analysis, system design, and system specifications were all based in large part on this excellent data effort. The fundamental design of an hierarchical architecture to support the FTD EW analyst is considered sound and the specifications produced under this effort are to be used in a follow-on effort for the full implementation of the EW-ETAS at FTD.

Marvin R. Clinch

MARVIN R. CLINCH
Project Engineer

1.0 INTRODUCTION

This Final Technical Report for the Electronic Warfare - Electromagnetic Threat Analysis System (EW-ETAS) was prepared to satisfy the requirements of paragraph 4.0 of the Statement of Work (SOW).

This effort was the development of a system to assist the FTD's analysts in their efforts to provide scientific and technical intelligence on Electronic Warfare and its threat. After progressing through the classic steps of systems development CSC was to demonstrate a system prototype using some subset of the full system capabilities.

The EW-ETAS effort began in July 1976 and was to end in July of 1978. However, contract amendments changed the program to a prototype demonstration on leased equipment at CSC and installation of the prototype software on equipment at FTD.

Individual subsystems were demonstrated and the prototype programs installed at FTD. The three operational subsystems (Intelligent Terminal, Graphics Terminal, and Desk Top Calculator) adequately demonstrated the soundness of the system development and design configuration. Future efforts that would implement a fully operational system will provide the FTD analyst with an invaluable tool in the analysis of EW information for scientific and technical intelligence.

Initially, this report discusses the original technical problem and the subsequent amendments which altered it. This is followed by the general methodology used in the development up through the software installation at FTD. Next, the technical results are covered by discussing each major subsystem. In the Special Comments section, problem areas plus two other areas are covered.

The two additional areas were the development of charts on status of the EW-ETAS programs and references and assumptions used in the software development. The charts are attached to the report. The final section of the report is the history of activities during the life of the contract.

2.0 REPORT SUMMARY

2.1 ORIGINAL TECHNICAL PROBLEM

The Electronic Warfare - Electromagnetic Threat Analysis System (EW-ETAS) design effort was initiated 30 June 1976 with a scheduled completion date of 23 July 1978. During this period, the contractor, Computer Sciences Corporation (CSC), was to execute the classic steps of system development:

1. Requirements analysis and verification
2. Development of the system concept
3. Detailed system design
4. Development of the system implementation plan
5. Development of system/subsystem specifications.

Additionally, CSC was to define some subset of the proposed system capabilities and demonstrate this prototype to the satisfaction of Rome Air Development Center (RADC) and Foreign Technology Division (FTD) personnel. No real deliverable capability was required, though it was assumed that a portion of the software developed for the demonstration could be usefully retained by FTD and actually used prior to the implementation of the proposed system.

2.2 AMENDMENTS TO PROBLEM

2.2.1 Background and Rationale

The design concept introduced a hierarchical structure of hardware and software capabilities to assist the EW analyst.

When further defined by the system functional description, it became apparent that the Digital Equipment Corporation (DEC) PDP 11/70 could be configured to meet the requirements of the EW-ETAS subsystem. At the time (summer 1977), it appeared that the Department of Defense (DOD) program for the AN/GYQ-21(V) offered the most expedient means for the acquisition of EW-ETAS hardware and therefore a Data Automation Requirement (DAR) document was initiated to obtain Headquarters, USAF, concept validation and funding support. Subsequently, it became apparent that the assumptions made concerning preparation, release, and approval of the DAR within the time of the contract were unrealistic.

2.2.2 Amendment No. 2 - 19 December 1977

This amendment changed the Statement of Work (SOW) to require assemblage of the necessary equipment for a prototype demonstration at CSC's facility.

2.2.3 Amendment No. 3 - 24 October 1978

It was anticipated that the computer would be installed at FTD by mid-1979 after approval of the DAR for the EW-ETAS minicomputer (GYQ-21(V)) by the Air Force. This resulted in another major change to the SOW. The change required installation on FTD's EW-ETAS hardware, those capabilities previously demonstrated. After installing and verifying the program, familiarization training would be provided to FTD analysts and computer operators.

2.3 GENERAL METHODOLOGY

2.3.1 Data Collection

The data collection effort (reported in the SECRET Data Analysis Report, dated March 1977, CDRL Number A005)

took place at FTD between July and September 1976. This effort allowed CSC to obtain the needed information on FTD's analysts requirements. The sources of data were from administration and management, from reviews and discussions of plans, logs, file records, study reports and other pertinent documents, from extensive interviews with the analysts, group leaders, and branch chiefs; and from meetings and briefings. The primary emphasis in the collection phase was the identification of bottlenecks in the analysis process.

2.3.2 Data Analysis

The analysis of the collected data took place in the period September 1976 through January 1977. The methodology used in this phase was to perform sensitivity and trade off analyses. The major areas of concern were analytical aids, models, data bases, computational capabilities and man machine interfaces. (Reported in the SECRET Data Analysis Report, dated March 1977, CDRL Number A005).

2.3.3 Survey of Systems

The major portion of the system survey began in September 1977 and was reported in the SECRET Data Analysis Report, dated March 1977, CDRL Number A005. After March, it continued at a reduced level throughout most of this effort. The survey covered government-owned and commercially available capabilities to determine if existing computer simulation models could be used to satisfy the concept design model requirements for EW-ETAS. The system selection was given in the Implementation Plan for the EW-ETAS, dated 1 September 1977, CDRL Number A004.

2.3.4 Concept Design

The Concept Design Report (CDRL A003) on this section was published in December 1976 and revised February 1977.

The systems objective of EW-ETAS based on the concept design would allow more prompt and confident performance of analysis tasks, maintenance of an up-to-date data base, and provide a simple, secure, and flexible administration of the intelligence data base. CSC's analysis resulted in the choice of hierarchical design as the most effective in meeting the EW-ETAS requirements.

2.3.5 Functional Description

The Functional Description Report for the EW-ETAS was published 1 June 1977 and was written to provide:

- The detailed system design description to serve as a basis for a mutual understanding between the user, Foreign Technology Division (FTD), and the developer, Computer Sciences Corporation (CSC).
- Information or system performance characteristics, implementation planning, and user impacts, to include fixed and continuing costs.

EW-ETAS was designed to be a dedicated analysis system that will provide FTD analysts with specific and general computational tools and analytical aids to achieve the following three major system objectives:

- Provide the analyst with a means to perform his task in a more timely manner with greater accuracy and confidence.
- Provide the capability to generate products in a more suitable form.
- Maintain an up-to-date data base of products, system vulnerabilities and susceptibilities, analytical aids, and models.

The system to accomplish these goals is comprised of the analyst, computational capabilities and analytical aids.

The computational capability provided by the system architecture is shown in Figure 2.3.5-1. This system ultimately will be integrated into the total FTD data processing system network. The major elements of this system are the minicomputer, intelligent terminals, graphics terminal, desktop calculator, maintenance terminals, X-Y plotters, and an associative file processor.

The analytical aids for EW-ETAS needed to solve a wide variety of problems were divided into four categories.

- Those related to radar analysis.
- Those related to the analysis of defensive weapons.
- Those related to analysis of ECM/ESM systems.
- Those common to analysis of more than one type system.

2.3.6 Implementation Plan

The Implementation Plan for the Electronic Warfare-Electromagnetic Threat Analysis System (EW-ETAS), dated 1 September 1977, CDRL Number A004, was written to fulfill the following:

- To provide guidance for the management and technical effort necessary throughout the implementation period.
- To coordinate with the user an orderly schedule of events, a specification of equipment and organizational requirements, the methodology of testing a list of deliverable materials, and a schedule of user orientation and training.

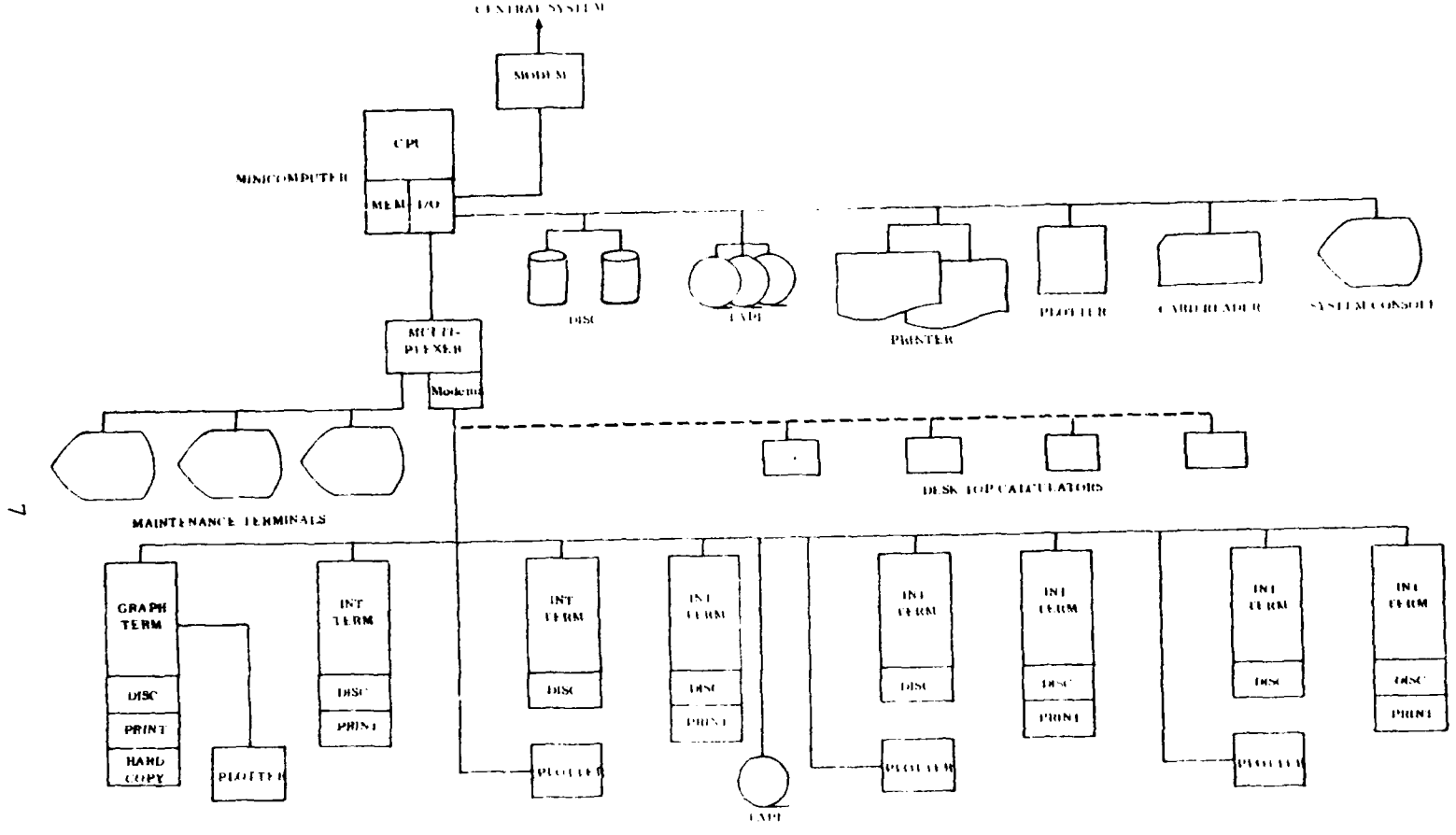


Figure 2.3.5-1 EW-ETAS System Architecture

The proposed system involved six basic elements: a minicomputer, intelligent terminals, graphics terminal(s), maintenance terminals, X-Y plotters and desk-top calculators. The design allowed incremental introduction of system modules that can be continued into the future.

2.3.7 Test and Evaluation

The test and evaluation of the prototype EW-ETAS was accomplished in two phases at CSC's location in Falls Church, Virginia. The prototype test plan for the EW-ETAS was written in two volumes, VOL I and II, dated 15 December 1977. Phase One was held from 29 January to 1 February 1979 and addressed testing and validation of the component and system performance. Phase Two was conducted from 26 February through 1 March 1979 and addressed the utility of the program interfaces to the analyst-user as well as testing the validity and accuracy of the program computation.

2.3.8 System/Subsystem Specifications

For all but one subsystem, the system/subsystem specifications were prepared for the following purpose: (All were published 29 March 1979 and will be discussed individually in 2.4.1, Overall Design).

- The detailed definition of the subsystem functions.
- Communicate details of the on-going analysis to the user's operational personnel.
- Define in detail the interfaces with other systems and subsystems and the facilities to be utilized for accomplishing the interfaces.

The one exception was the specification for the Knowledge Base Subsystems. This was the RAVEN Knowledge Base Enhancement which will provide FTD's analysts with a computer support

system for a more timely information retrieval, more accurate modeling, and higher confidence in available multisource information search. Specifically, RAVEN will satisfy the countermeasures analysts top priority requirements for high speed, interactive multisource reference and information retrieval using high speed Associative File Processor hardware to replace a tedious and overwhelming manual procedure.

2.3.9 Software Installation and Verification

As directed by the final change to the SOW, CSC personnel installed and verified the prototype programs at FTD. After the programs were operational on the Government Furnished Equipment (GFE), FTD analysts and computer operators were to be given on-the-job training in the prototype systems.

2.4 TECHNICAL RESULTS

2.4.1 Overall Design

The data study of FTD's structure for EW analysis revealed a manual system with many inherent bottlenecks and delays. The EW-ETAS program called for the design of a complete system and demonstration of a subset of its capabilities in a prototype. Although a completed system is not operational, prototype results clearly indicate that the EW-ETAS will:

- Give the analyst more accuracy, confidence and timeliness in performing his tasks.
- Provide products for the analyst in a more suitable and useful form.
- Maintain an updated product data base on the various subsystems as shown graphically in the Section 2.6.2. Comments on problem areas will also be covered in Section 2.6.1.

2.4.2 Intelligent Terminal

The programs installed on this subsystem and their status are covered in Section 2.6.2. The specifications are listed in Analytical Applications System Intelligent Terminal Subsystem Specification, A009, dated 30 March 1979.

2.4.3 Graphics Terminal

The prototype programs were installed on this subsystem in September 1979. Since that time there have been few reports from the analysts on this device. The programs installed and their latest status are shown in Section 2.6.2 of this report. The specifications are in the Analytical Applications System Graphics Terminal Subsystem Specifications, A009, dated 30 March 1979.

2.4.4 Desk Top Calculator

This subsystem is working well using the prototype programs developed by CSC. The latest status of the programs are in Section 2.6.2 of this report. The specifications are in the Analytical Applications System Desk Top Calculator Subsystem Specification, A009, dated 30 March 1979.

2.4.5 Minicomputer

Although specifications and some programs were written for this subsystem, a lack of equipment prevented any of the programs from being installed and used by FTD. The status of the program is shown in Section 2.6.2 The specifications are in the Analytical Applications System Minicomputer Subsystem Specifications, A009, dated 30 March 1979.

2.4.6 Central Computer (UNIVAC-1011)

Some work was done in the programs for the FTD Central Computer, but none were installed at FTD. The specifications

for this system are in the Analytical Applications System Central Computer Subsystem Specification A009, dated 30 March 1979.

2.5 NEED FOR FURTHER RESEARCH AND DEVELOPMENT

In this contract the need for EW-ETAS as an analytical tool was clearly perceived. While the efforts in testing, evaluating and installing a prototype capability gave FTD's analysts an idea of what the systems could do as an analysis aid, the full system in complete or partial operation was not demonstrated. Until a complete EW-ETAS is installed and demonstrated, the analyst will not really have available all required capabilities. The EW-ETAS effort should continue with an implementation contract.

2.6 SPECIAL COMMENTS

2.6.1 Problem Areas

This contract had one significant problem area. The government furnished hardware that was of a different configuration than that used to develop the software. This caused considerable perturbations and delays in the software verification and installation. This situation should be carefully considered in future developments.

2.6.2 Program Status Charts

The following charts on the status of programs on the subsystem are attached as Appendix A.

2.6.3 Computer Program References and Assumptions

Appendix B of this report contains charts with the references and assumptions used for development of EW-ETAS programs.

3.0 CONTRACT HISTORY

This section will provide a brief summary of the most significant activities during the period of the contract. Detailed information was provided in monthly reports.

3.1 JULY-DECEMBER 1976

After a "kick-off" meeting at CSC, systems analysts went to FTD to start the data collection. Concurrently, the computer model survey was initiated. After completion of the data collection, work commenced on the Data Analysis Report (A005). In October, work on the Concept Design Report (A003) was begun. The Concept Design Report was published on 1 December 1976. The Data Analysis Report was scheduled for completion in March 1977.

3.2 1977

The Concept Design Report was briefed at FTD and incorporation of requested revisions were completed and delivered in February. The Functional Description and Implementation Plan delivery dates were set for 1 May and 1 June 1977, respectively. The computer modeling survey continued. Numerous government and industry sources for models suitable for use in EW-ETAS were surveyed. The Data Analysis Report (A005) was completed in March. Discussions started on information for the Data Automation Request (DAR) for Government Furnished Equipment (GFE) for EW-ETAS. The delivery date of the Implementation Plan was delayed at RADC's request pending resolution of the EW-ETAS hardware procurement approach. The Functional Description (A008) was delivered in June. Work on the Prototype System/Subsystem Specifications also started in July. Also in July, a Hewlett-Packard desk top calculator was leased and some of the EW-ETAS programs were installed on it. In September the Implementation

Plan (A004) and data inputs to the revised DAR were submitted. Work started and continued on specifying those capabilities to be included in the prototype implementation. This included capabilities for the desk-top calculator.

3.3 1978

By February, the System/Subsystem Specifications were 60% complete. An Engineering Change Proposal (ECP) was submitted to RADC to extend the contract through 1978 and expand the prototype capabilities demonstration. An Interim Prototype Capability demonstration of the desk-top calculator was completed. By May and after some revision the ECP was approved and actions were begun to lease equipment for the prototype demonstration. In June the Prototype System/ Subsystem Specifications were completed and the final revision was delivered in July. In June the intelligent terminal for the demonstration was installed at CSC. In July the Graphics Terminal was received and installed. The selected DEC time sharing system was rarely available after September essentially depriving CSC of a Minicomputer (PDP-11/70) for use in EW-ETAS. Unanticipated down time in this system continued through the rest of the year. This severely retarded minicomputer subsystem software development. Work on other subsystems software development continued through the end of the year. The Prototype Test and Evaluation Plan (A012) was completed in December.

3.4 1979

In January the first test of the prototype capabilities was run. In February the second prototype test and evaluation was completed. Results were forwarded to RADC. In March work continued to complete the deliverable items. An amendment to the contract was received that covered prototype

implementation at FTD. In April the System/Subsystem Specification (A009) and Program Specifications (A010) were delivered. Further progress in the contract was delayed awaiting the delivery of GFE to FTD. In July the Training Course Outline (A015) was completed and forwarded. The GFE was delivered to FTD in August. In September, CSC personnel traveled to FTD to install the software on the GFE and train FTD personnel. There were no significant problems with the Desk Top Calculator and the Graphics Terminal. The configuration of the Intelligent Terminal was not the same as that used in the test at FTD and the approved software would not function on it. This final problem prevented the completion of the contract on schedule. A no-cost contract extension until 31 December 1979 was requested and FTD completed modification of its intelligent terminal to the same configuration as that used in the tests.

3.5 JANUARY - MAY 1980

In January a verbal agreement was reached to extend the contract at no cost to the government until 29 February 1980. On 24 January 1980 program documentation was furnished to RADC. The Desk Top Calculator was also shipped to RADC. CSC visited FTD twice in February. On the second trip considerable progress was made and nearly all the prototype programs became functional on the Intelligent Terminal. In agreement with RADC one further trip was made to FTD to attempt to correct any remaining problems and train additional FTD personnel. In April 1980 the final Technical Report was drafted as the final step in the contract. After RADC comments were included, the final Technical Report was rewritten and forwarded.

APPENDIX A

PROGRAM STATUS CHARTS

	INTELLIGENT TERMINAL PROGRAM NAME/ ABBREVIATION	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
1.	ALGEBRAIC Analysis		X					
2.	Matrix Inversion (MATINV)	X			X			
3.	Simultaneous Eqs (MATSIM)	X			X			
4.	Integration of Equally Spaced Data Points (INTDAE)	X			X			
5.	Differentiation of Equally Spaced Data Points (INTDFE)	X			X			
6.	FAST Solution of FIRST Order Differential Eqs (DIFFAS)		X					
7.	Fourier Coefficients for Equally Spaced Data (FOUDAE)	X			X			
8.	Basic Statistical Parameters (MEANS, VARIANCE, MOMENTS, ETC) (STAPAR)	X			X			
9.	Curve Fitting Family Regression (REGFAM)	X			X			
10.	Probability Distribution Function, Normal Dist. (DISNOR)	X			X			
11.	Prob. Dist. Chi-Square Distribution (DISCHI)	X			X			
12.	Random Number Generators (RANUNI)	X			X			
13.	Stat. Tests, Chi-Square Test of Exp. Freq (TESCHI)	X			X			
14.	RADAR RANGE Equations 6 Options (RARNG)	X			X			
15.	Location Ellipse	X			X			
16.	Ostacle Path Loss	X			X			
17.	Emplos Procedure Form Path-loss 1-18000 MHB ECAC I-1	X			X			
18.	ECAC I-2 OFR Pulsed	X			X			
19.	ECAC I-3 OFR ANALOG	X			X			
20.	S/N, I/N, S/I Ratios ECAC I-4 (SNINSI)	X			X			
21.	GEO to UTM CONV (ECAC I-7)	X			X			
22.	UTM to GEO CONV (ECAC I-8)	X			X			
23.	Run Stream Generator ANTPAT	X						X
24.	Personal Data Base	X						X
25.	Radar Worksheets 1 (RNGSNR)	X			X			
26.	Radar Worksheets 2 (RNGVF)	X			X			
	(The Following Programs Were Not Listed as Deliverables in The Prototype Contract)							
27.	Transfer Functions		X					
28.	Super-Sceptre RSG		X					
29.	Optmizations		X					
30.	Wave Form Analysis (WAFALS)		X					
31.	RGFALC		X					
32.	Lobe Plot		X					
33.	MTI Blind Speed		X					
34.	SURSEM		X					
35.	SIGPLOT		X					

APPENDIX A (CONT'D)

PROGRAM STATUS CHARTS

	INTELLIGENT TERMINAL PROGRAM NAME/ ABBREVIATION	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
36.	COFLARAY		X					
37.	E^4		X					
38.	Moving Target Trajectories (MTT)		X					
39.	IR Cross Sections		X					
40.	SAM Simulators		X					
41.	SAM Encounters		X					
42.	MIMIC RSG		X					
43.	Knowledge Base (RAVEN)		X					
44.	Interpretation of Equations		X					
45.	Roots of Polynominal Eqs		X					
46.	Roots of General Eqs		X					
47.	Minimum Values of an Eq		X					
48.	Integration of an Eq		X					
49.	Differentiation of an Eq		X					
50.	Fourier Transform of an EQ		X					
51.	Matrix Addition		X					
52.	Matrix Subtraction		X					
53.	Matrix Multiplication		X					
54.	Scalar Multiplication		X					
55.	Row Sort by Column		X					
56.	Column Sort by Row		X					
57.	Int. of Unequally Spaced Data Points		X					
58.	Diff. of Unequally Spaced Data Points		X					
59.	Hi ACC Soln of Diff. Eq.		X					
60.	Fourier Coeff. for Uneq. Data		X					
61.	Equal Interval Freq Tables (HISTOGRAMS)		X					
62.	Unequal Interval Freq. Tables		X					
63.	Linear Regression		X					
64.	Quadratic Regression		X					
65.	Polynomial Regression		X					
66.	Cubic Spline Regression		X					
67.	Multiple Linear Regression		X					
68.	Inverse Normal Out Funct.		X					
69.	Poisson Distribution Funct.		X					
70.	T-Distribution Function		X					
71.	F-Distribution Function		X					
72.	Normal Distribution		X					
73.	One-Tailed T Test		X					
74.	Two-Tailed T Test		X					
75.	One-Way Analysis of Variance		X					
76.	Two-Way Analysis of Variance		X					
77.	Bearing and Distance Between Geographic Locations		X					
78.	Geographic Location Given A Bearing & Distance		X					
79.	Topographic Profile Analysis		X					

APPENDIX A (CONT'D)

PROGRAM STATUS CHARTS

	INTELLIGENT TERMINAL PROGRAM NAME/ ABBREVIATION	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
80.	Path Loss (Ground Wave)		X					
81.	Path Loss (Cosite Terrestial)		X					
82.	Path Loss (Aircraft Antennas)		X					
83.	Free Space Path Loss		X					
84.	Intermodulation-Free Freqs		X					
85.	Harmonic-Free Frequencies		X					
86.	Radar Emission Bounds		X					
87.	Radar Emission to OTP Standards		X					
88.	Phase Derived Coded Pulses		X					
89.	Data Base Navigation	X					X	
90.	Data Base Query		X					
91.	Index of Queries		X					
92.	Index of Reports		X					

APPENDIX A (CONT'D)

PROGRAM STATUS CHARTS

GRAPHICS TERMINAL	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
1. Algebraic Analysis		X					
2. Matrix Inversion (MATINV)	X				X		
3. Simultaneous Equations (MATSIM)	X						X
4. Integration of Equally Spaced Data Points (INTDAE)	X						X
5. Differentiation of Equally Spaced Data Points (INTDFE)	X						X
6. Fast Solution of First Order Differential Equations (DIFFAS)		X					
7. Fourier Coefficients For Equally Spaced Data (FOUDAE)	X						X
8. Basic Statistical Paramaters (STAPAR)	X						X
9. Curve Fitting Family Regression (REGFAM)	X						X
10. Probability Distribution Function (DISNOR)	X						X
11. Prob. Dist. Funct. Chi-Square Dist. (DISCHI)	X						X
12. Random Number Generators (RANUNI)	X			X			
13. Statistical Tests, Chi-Square Test of Expected Freq. (TESCHI)	X						X
14. Radar Range Equations (RARNG)	X						X
15. Location Ellipse	X			X			
16. Obstacle Path Loss	X				X		
17. ECAC I-1 (EMPLOS)	X			X			
18. ECAC I-2 OFR Pulsed	X			X			
19. ECAC I-3 OFR Analog	X						X
20. ECAC I-4 SNINSI	X			X			
21. ECAC I-7 GEO to UTM Conv	X			X			
22. ECAC I-8 UTM to GEO Conv	X			X			
23. Circuit Graphics	X						X
24. Diagram Graphics	X						X

APPENDIX A (CONT'D)

PROGRAM STATUS CHARTS

	MINI COMPUTER (PDP-11/70)	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
1.	Algebraic Analysis		X					
2.	Matrix Inversion (MATINV)		X					
3.	Simultaneous Eqs (MATSIM)		X					
4.	Integration of Equally Spaced Data Points (INTDAE)		X					
5.	Differentiation of Equally Spaced Data Pts. (INTDFE)		X					
6.	Fourier Coefficients for Equally Space Data (FOUDAE)		X					
7.	Basic Statistical Parameters (STAPAR)		X					
8.	Curve Fitting, Family Regression (REGFAM)		X					
9.	Probability Dist. Function Normal Dist. (DISNOR)		X					
10.	Probability Dist. Function Chi-Square (DISCHI)		X					
11.	Random Number Generators (RANUNI)		X					
12.	Statistical Tests, Chi-Square Test of Freq. (TESCHI)		X					
13.	Radar Range Equations (6 Options) (RARNG)		X					
14.	Location Ellipse		X					
15.	Obstacle Path Loss		X					
16.	Fast Solution of First Order Differential Eqs (DIFFAS)		X					
17.	Surveillance Radar System Evaluation Model (SURSEM)			X				
18.	RG CALC			X				
19.	SIG PLOT			X				
20.	LOBE PLOT			X				
21.	COPLARAY			X				
22.	BITE FIND		X					

APPENDIX A (CONT'D)

PROGRAM STATUS CHARTS

DESK TOP CALCULATOR	1 Program Delivered	2 Program Not Delivered	3 Program Delivered Not Tested	4 Functions Properly	5 Functions With Minor Problems	6 Function Not Rigorously Tested	7 Does Not Function
1. Algebraic Analysis		X					
2. Matrix Inversion (MATINV)	X			X			
3. Simultaneous Eqs (MATSIM)	X			X			
4. Integration of Equally Spaced Data Points (INTDAE)	X			X			
5. Differentiation of Equally Spaced Data Points (INTDFE)	X			X			
6. Fourier Coefficients for Equally Spaced Data (FOUDAE)	X			X			
7. Basic Statistical Parameters (Means, Variance, Moments, etc.)(STAPAR)	X			X			
8. Curve Fitting, Family Regression (REGFAM)	X			X			
9. Probability Distrubution Function, Normal Dist. (DISNOR)	X			X			
10. Prob. Dist. Function Chi-Square Dist. (DISCHI)	X			X			
11. Random Number Generators Uniform Dist. (RANUNI)	X			X			
12. Statistical Tests, Chi-Square Test (TESCHI)	X			X			
13. Radar Range Equations, 6 Options (RARNG)	X			X			
14. Location Ellipse	X			X			
15. Obstacle Path Loss	X			X			
16. ECAC I-1 (EMPLOS)	X			X			
17. ECAC I-2 (OFR PULSED	X			X			
18. ECAC I-3 OFR ANALOG	X			X			
19. ECAC I-4 SNINSI RATIOS	X			X			
20. ECAC I-7 GEO to UTM	X			X			
21. ECAC I-8 UTM to GEO	X			X			
22. ECM Equations (4 Programs)	X			X			

APPENDIX B

COMMON PROGRAMS - GRAPHICS & INTELLIGENT TERMINALS

PROGRAM NAME/ABBREV.	REFERENCES OR SOURCE OF PROBLEM
1. MATRIX INVERSION (MATINV)	No reference required, standard mathematical procedure. Author Neil Kurland, Computer Sciences Corporation. Assumption: Gaussian elimination is used.
2. SIMULTANEOUS EQUATIONS (MATSIM)	Same as MATINV, above.
3. INTEGRATION OF EQUALLY SPACED DATA POINTS (INTDAR)	Hewlett-Packard General Utility Routines, Part No. 09825-10000 Carnahan, Luther and Wilkies, Applied Numerical Methods Pages 70-74 John Wiley & Sons, Inc. Assumption: The array F(I) should contain the N functional values in increasing order of domain value. Data points must be an odd number and equally spaced. Integration limits A and B are coincident with base points.
4. DIFFERENTIATION OF EQUALLY SPACED DATA POINTS (INTDFE)	Hewlett-Packard General Utility Routines Part No. 09825-10000 Assumption: The data points should be entered in increasing order of domain values. The arguments to be differentiated may be entered in order, but should be in the interval of the data points.
5. FOURIER COEFFICIENTS FOR EQUALLY SPACED DATA (FOUDAE)	Hewlett-Packard General Utility Routines, Part No. 09825-10000 Hamming, R.W., Numerical Methods for Scientists and Engineers, Pages 67-69 McGraw-Hill Book Company

5.	FOURIER COEFFICIENTS FOR EQUALLY SPACED DATA (FOUDAE) (CONT'D)	Assumptions: The array F must contain the N functional values in increasing order of domain rules. The number of data points must be odd.
6.	BASIC STATISTICAL PARAMETERS (STAPAR)	Hewlett-Packard Statistical Library - 1, Part No. 09815-15030.
7.	CURVE FITTING FAMILY REGRESSION (REGFAM)	Hewlett-Packard Statistical Library - 1, Part No. 09815-15030 Draser, N.R. and Smith, H. Applied Regression Analysis Pages 7-13, 128-134 John Wiley and Sons, Inc. Assumptions: All data must be positive.
8.	PROBABILITY, DISTRIBUTION FUNCTION (DISNOR)	Hewlett-Packard Statistical Library - 1, Part No. 09815-15030
9.	PROBABILITY DISTRIBUTION FUNCTION, CHI-SQUARE DISTRIBUTION (DISCHI)	Hewlett-Packard Statistical Library - 1, Part No. 09815-15030 (Note program used in unmodified form.)
10.	RANDOM NUMBER GENERATOR (RAN UNI)	Carnahan, Luther and Wilkies Applied Numerical Methods Pages 546-549 John Wiley and Sons, Inc. Assumptions: The variable IODD is an odd integer number less than 32767.
11.	STATISTICAL TESTS, CHI-SQUARE TEST OF EXPECTED DISTRIBUTION (TESCHI)	Carnahan, Luther and Wilkies Applied Numerical Methods Pages 562-566 John Wiley and Sons, Inc.
1..	RADAR RANGE EQUATIONS (RARNG)	Adopted from a program created for the HP 9825, Desk Top Calculator by Neil Kurland, Computer Sciences Corporation. Assumptions: All inputs are in DB units.

13.	LOCATION ELLIPSE	Created by Neil Kurland from Analyses by Charles Fruchter. Both are Computer Sciences Corporation employees. Basis for the analyses was ECAC documents "EMC Analysis Capabilities for Programmable Calculators" (ECAC-PD-75-001 and 002) DOD, ECAC, Annapolis, Maryland 24402
14.	OBSTACLE PATH LOSS	This program was developed the same as the previous program, Location Ellipse.
15.	ECAC I-1 (EMPLOS) ECAC I-2 (OFR PULSED) ECAC I-3 (OFR ANALOG) ECAC I-4 (SNINSI) ECAC I-7 (GEO TO UTM CONV) ECAC I-8 (UTM TO GEO CONV)	All ECAC programs were modified from those given in the following documents: EMC Analysis Capabilities for Programmable Calculators, (ECAC-PD-75 001 and 002) DOD, ECAC, Annapolis, Marvland 24402 The assumptions used in the ECAC programs are listed below: ECAC-1 - The model used to calculate basic transmission loss might be described as a "ground wave" model augmented in troposcatter calculations for long distances. Ground wave in this case is meant to include the effects of the surface wave and multipath phenomena. The model considers a combination of ray, surface wave, diffraction and tropo-scatter phenomena and is applicable over all distances within its range (approximately 1.6 to 483.1 kilometers). The model is not applicable for sky wave propagation, nor does it consider the effects of

15. ECAC I-1 (EMPLOS) (CONT'D) ducting sky wave phenomena, detailed topography or foliage.
ECAC I-2 (OFR PULSED)
ECAC I-3 (OFR ANALOG)
ECAC I-4 (SNINSI) ECAC I-2 and I-3 - Based on idealized transmitter spectrum and receiver selectivity curves.
ECAC I-7 (GEO TO UTM CONV)
ECAC I-8 (UTM TO GEO CONV)

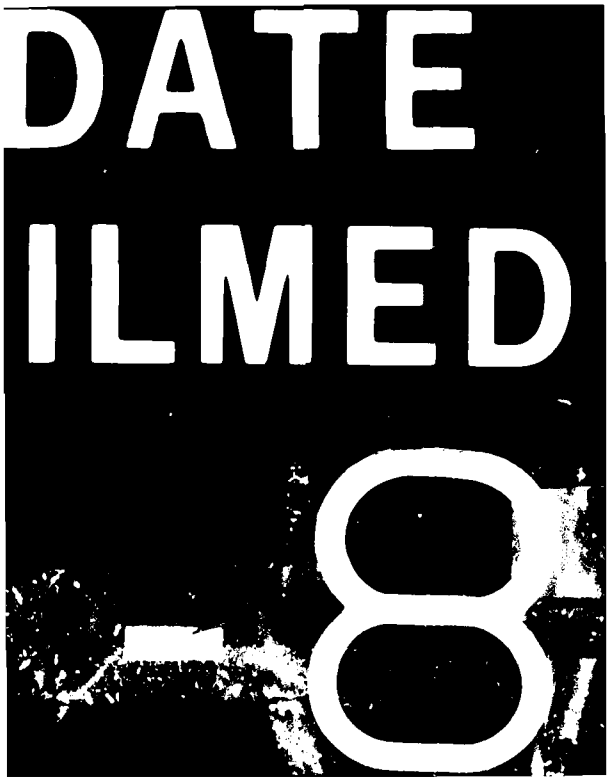
ECAC I-7 and ECAC I-8 - The analysis involved in the conversion from geographic to universal transverse mercator (UTM) coordinates assumes that the surface of the earth can be represented by a series of spheroids. The spheroid representations are different in different parts of the world because the surface of the earth does not everywhere conform to a single spheroid. For example, in the Continental United States the Clarke 1866 spheroid is used; the international spheroid is used in Europe. Proper use of this program requires the correct identification of the appropriate spheroid.

UNIQUE DELIVERED PROGRAMS - INTELLIGENT TERMINAL

PROGRAM NAME/ABBREV.	REFERENCES/ASSUMPTIONS
RADAR WORKSHEETS 1 (RNGSNR)	SDER Radar Worksheets, Signal to Noise Version
RADAR WORKSHEETS 2 (RNGVF)	SDER Radar Worksheets, Visibility Factor Version
	GRAPHICS TERMINAL
CIRCUIT GRAPHICS DIAGRAM GRAPHICS	Adapted from Tektronix's manuals by CSC
	DESK TOP CALCULATOR
ECM EQUATIONS	Developed by CSC for Desk Top Basic Equations are: One-way propagation, continuous noise jamming Standoff jamming Self-screening Self-interference

MISSION
of
Rome Air Development Center

RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of technical competence is provided to ESD Program Offices (POs) and other ESD elements. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.


DATE
ILMED
8